AD-A188 936 POLAR MESOSPHERIC CLOUD EXPERIMENT(U) COLORADO UNIV AT BOULDER LAB FOR ATMOSPHERIC AND SPACE PHYSICS G E THOMAS 21 SEP 87 N00014-86-K-0535 1/1

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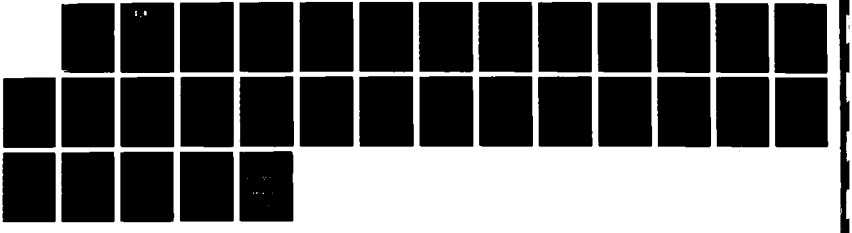

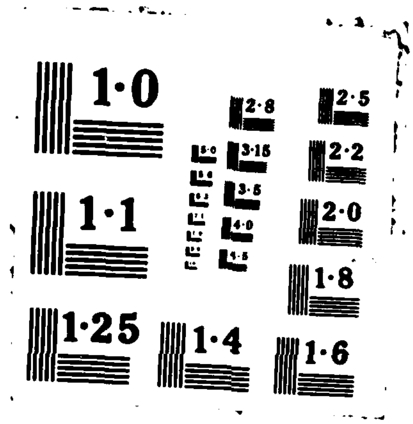
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6c. ADDRESS (City, State and ZIP Code)	7b. ADDRESS (City, State and ZIP Code)
Laboratory for Atmospheric and Space Physics Campus Box 392, University of Colorado Boulder, CO 80309-0392	800 North Quincy Street Arlington, VA 22217-5000

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Gary E. Thomas, P.I.

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FIELD	GROUP	SUB. GR.	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This project consists of the design and fabrication of a satellite-borne ultraviolet atmospheric experiment. The components of the instrument will both image and make quantitative polarization measurements of the scattered light from polar mesospheric clouds (PMC) occurring in the high-latitude summertime mesosphere at heights of 85 km. Its scientific objectives are: (1) to determine the morphology, scattering and attenuation properties, occurrence frequency statistics, and statistical distribution of spatial scales of PMC and other aerosol layers in the upper mesosphere; (2) to derive information on the atmospheric wave activity in the summertime mesosphere over all horizontal spatial scales greater than about 2 kilometers; and (3) to determine the mean particle size of PMC particles, to characterize its dependence on latitude, longitude, wave activity and PMC brightness.

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ANNUAL REPORT
PMC EXPERIMENT

This project was approved in mid-1986, and funded in September, 1986 through September 30, 1988. The total value of the contract is $751,000, of which $326,000 has been received (as of June, 1987). During the first phase of the contract, we conducted a study of the scientific requirements, rationale and observational strategy for the various experiment modules. This has resulted in a firm set of requirements for the three imaging experiments: (1) wide-angle (morphology) imaging experiment, (2) narrow-angle (waves) imaging experiment, and (3) nadir-viewing (high-resolution) imaging experiment. A summary of the functional requirements for each of the above is given in Enclosure 1.

The functional requirements for the fourth and fifth modules are currently being defined. These experiments are (4) microphysics (UV polarization) experiment, and (5) mesopause temperature experiment.

Detailed engineering design efforts are now underway for experiments (1) - (3). To briefly summarize these designs to date: the UV imagers which view the limb [(1) and (2)] have anamorphic lenses to obtain images stretched by a factor of 10:1 in the direction parallel to the horizon. This more closely matches the inherent resolution of limb sounding in the horizontal plane, and also maximizes the light input. They also contain image intensifiers and reticon image sensors (64 x 64 pixels). UV bandpass filters will limit the spectral resolution to the vicinity of 265 nm. The nadir imager has 2 UV transmitting lens, and a one-dimensional reticon detector (1 x 100 pixels).

The three UV imagers will provide sequences of images from which a three-dimensional cloud scene can be generated. The entire polar cap area around each summer pole can be mapped once per day, provided the experiment is flown on a low circular, polar orbiter. At the center of each low-resolution strip, a moderate-resolution image will magnify the scene. At the center of each moderate-resolution image will be a high-resolution image. This nesting will give successive magnifications, or 'zoom' factors which provide a continously-varying resolution down to the smallest scales (about 2 km). The various coverages and resolutions of each imager is described in Enclosure 1.

ACTIVITIES DURING THE YEAR (1986 - mid 1987)

(1) The University of Colorado played host to an S.D.I. Workshop on the Middle Atmosphere on November 17-18, 1986. A copy of the agenda and a list of participants is enclosed.

(2) The Principal Investigator, G. E. Thomas, attended a meeting held at Riverside Research Institute in Arlington, Va. The purpose of the meeting was to brief various S.D.I. representatives on the research program on the natural environment within the Innovative Science Program of S.D.I.

(3) In response to a possible opportunity for our experiment to be carried on board a French satellite in 1989, we performed an exercise in which we proposed to S.D.I. to fly a scaled-down experiment consisting of two UV imagers. We provided cost, weight, power, envelope and telemetry requirements to the Program Director, Paul Twitchell, and to Col. Arthur Boright, both of S.D.I.

ENCLOSURES

ENCLOSURE 1. Functional requirements for Morphology, Waves and Nadir Imagers
ENCLOSURE 2. Agenda for November 17-18, 1986 Workshop in Boulder, Colorado.
ENCLOSURE 3. List of attendees at Boulder Workshop.
ENCLOSURE 4. Copy of overhead transparencies presented at Boulder Workshop

ENCLOSURE 1.

FUNCTIONAL REQUIREMENTS FOR MORPHOLOGY, WAVES AND NADIR IMAGERS

TABLE IV-1

MORPHOLOGY

This section of the experiment creates low resolution images which will cover the entire pole giving an overall picture. The purpose of the morphology experiment is to map the location and brightness of the clouds over the entire pole. It will find the variation of clouds in time, location and altitude.

(1) ALTITUDE	
(A) RESOLUTION	3.3 km sample
(B) COVERAGE	70 - 100 km (64 samples total, 8 selected and transmitted)
(C) CONTRAST	10:1 min
(2) WAVELENGTH	
(A) RESOLUTION	20 nm
(B) COVERAGE	1 wavelength, 265 nm
(3) HORIZONTAL	
(A) RESOLUTION	33 km sample
(B) COVERAGE	2000 km (45° FOV) in 64 samples (to big for lense)
(C) CONTRAST	10:1 min
(4) POLARIZATION	not needed
(5) LIMBS	Forward limb only.
(6) SAMPLE CYCLE TIME	12 sec (100 km) (integration time < 12 sec)
(7) SENSITIVITY NEEDED	dim cloud 10 kR/A bright cloud 1000 kR/A
(8) PRECISION NEEDED	10% (repeatability and noise for scattered light greater than 10kR/A
(9) ACCURACY NEEDED	20% to map cloud brightnesses (absolute calibration)
(10) POINTING	Knowledge: 2 km (0.06 degrees) Real time: 100 Km (3 degrees)
(11) BIT RATE	0.34 kilobits/sec (8×64 8 bit words/12 sec)

NOTE: These are preliminary functional requirements and are subject to change.

September 21, 1987

TABLE IV-2

WAVES ON THE LIMB

The waves or dynamics section of the experiment makes higher resolution images (a zoom factor of 8 from the Morphology experiment) of the PMC's to examine and understand the atmospheric waves that are often seen in ground observations.

(1) ALTITUDE	
(A) RESOLUTION	0.4 km sample
(B) COVERAGE	80-88 km (64 samples total, select and transmit 20)
(C) CONTRAST	10:1 min
(2) WAVELENGTH	
(A) RESOLUTION	20 nm
(B) COVERAGE	1 wavelength, 265 nm
(3) HORIZONTAL	
(A) RESOLUTION	4 km sample
(B) COVERAGE	250 km (5.6 degrees) in 64 samples
(C) CONTRAST	10:1 min
(4) POLARIZATION	not needed
(5) LIMBS	Forward limb only; centered on Morphology exp.
(6) SAMPLE CYCLE TIME	1 sec (7 km)
(7) SENSITIVITY NEEDED	dim cloud 10 kR/A bright cloud 1000 kR/A
(8) PRECISION NEEDED	10% (repeatability and noise for scattered light greater than 10kr/A
(9) ACCURACY NEEDED	20% to map cloud brightnesses (absolute calibration)
(10) POINTING	Knowledge: 2 km (0.06 degrees) Real time: 10 km (0.30 degrees, this may require our own pointing)
(11) BIT RATE	10.3 kilobits/sec (20×64 8 bit words/sec)

TABLE IV-3

WAVES IN THE NADIR

The nadir experiment will collect high resolution images along a 64 km swath at the sub-satellite point. This experiment is particularly valuable during twlight conditions when the shadow height exceeds 70 km above the earth's surface.

(1) WAVELENGTH	
(A) RESOLUTION	20 nm
(B) COVERAGE	1 wavelength, 265 nm
(2) HORIZONTAL	
(A) RESOLUTION	2 km (1×1 km samples)
(B) COVERAGE	64 km in 64 samples
(C) CONTRAST	100:1 min *
(3) POLARIZATION	not needed
(4) SAMPLE CYCLE TIME	0.14 sec (1 km along the orbit track)
(5) SENSITIVITY NEEDED	dim cloud 0.1 kR/A bright cloud 10 kR/A Rayleigh background 2-7 kR/A
(6) PRECISION NEEDED	1% (repeatability and noise for scattered light greater than 1 kR/A
(7) ACCURACY NEEDED	none
(8) POINTING	2 km (0.2 degrees)
(8) POINTING	Knowledge: 2 km (0.2 degrees) Real time: 30 km (3 degrees)
(9) BIT RATE	7.68 kilobits/sec (64 12 bit words/0.1 sec)

* we want to know that a 1% change in the observed radiance is real

ENCLOSURE 2.

AGENDA FOR NOVEMBER 17-18, 1986 WORKSHOP IN BOULDER, COLORADO

AGENDA

MIDDLE ATMOSPHERIC WORKSHOP
17-18 NOVEMBER 1986
UNIVERSITY OF COLORADO
LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS (LASP)
55th STREET FACILITY
BOULDER, COLORADO

PLENARY SESSION

0830	Welcome Gary Thomas
	Introduction Paul Twitchell
	SDIO Overview Col. A. Boright, USAF, Special Assistant to the Deputy for Programs and Systems
	Middle Atmosphere Dynamics Cambridge University, P.H. Haynes
	BREAK
	Sensors and Electro-optical Phenomenology SDIO Sensors Office, B. Katz
	Density Variability in Middle Atmosphere NASA/Marshall Space Flight Center, D. Johnson, S. Smith
	Navy Middle Atmosphere Program NRL, D. Anderson and R. Conway
	Stellar Horizon Atmospheric Dispersions ONR Boston, F. Quelle
1130	LUNCH

DYNAMICS

1300	Breaking Internal Gravity Waves Gould Defense Systems, Newport, RI, J.B. Grant
	Processes Responsible for Variability of Stratosphere and Mesosphere Florida State University, R.L. Pfeffer and A.I. Barcilon
	Gravity Wave Variability, Saturation, and Turbulence Generation in the Mesosphere and Lower Thermosphere University of Alaska, D.C. Fritts
	BREAK
	Ultrafast Algorithms for Cloud Data Analysis METSAT Inc., Fort Collins, CO, T.H. Vonder Haar and T.A. Brubaker
	Cloud Cover over North America University of Wisconsin, Madison, WI, V. Suomi, D.P. Wylie and E.W. Eloranta
	Cubic Ice in Atmosphere Desert Research Institute, Reno, NV, W.G. Finnegan and R.L. Pitter
	Microphysical Studies of Noctilucent Clouds State University of New York, B. Vonnegut and A.F. Roddy
1600	Working Groups and Charter defined, participants identified and spokesman selected
1630-1730	Tour of Solar Mesosphere Explorer (SME) Operations Facility

OBSERVATIONAL TOOLS

0830	Properties, Constituents and Clouds of Middle Atmosphere University of Wyoming, T.J. Pepin Compact Lidar Systems University of Maryland, T.D. Wilkerson Polar Mesosphere Clouds Structure Utah State University, J.C. Ulwick Polar Mesosphere UV Imaging University of Colorado-Boulder, G. Thomas BREAK Working Groups Convene* Dynamics Cloud Physics Observational Working Group Spokesman Report Structured Workshop adjourns Working space will be available for follow-on discussions by participants
1400	SDIO/IST Natural Environment "White Paper" Evaluation Committee Meeting

*While working groups convene, Government Managers will briefly meet

ENCLOSURE 3.

LIST OF ATTENDEES AT BOULDER WORKSHOP

PARTICIPANTS AT THE MIDDLE ATMOPSHERE WORKSHOP
LASP - UNIVERSITY OF COLORADO, 17-18 NOVEMBER 1986

NAME	ORGANIZATION (MAILING ADDRESS)	PHONE NUMBER
Boright, Art	USAF - OSD/SDIO Innovative Science and Technology Washington, DC 20301-7100	(202) 653-0572
Brubaker, Thomas A.	METSAT, Inc. 515 S. Howes Fort Collins, CO 80521	(303) 221-5420
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Dunmire, Tom	SD/WE Los Angeles AFS Los Angeles, CA 90009-2960	(213) 643-0304
Eloranta, Edwin	Dept. of Meteorology University of Wisconsin Madison, WI 53706	(608) 262-7327
Finnegan, William	Desert Research Institute Reno, NV 89506	(702) 972-1676
Fritts, Dave	Geophysical Institute University of Alaska Fairbanks, AK 99775-0800	(907) 474-7845
Grant, John	Gould Defense Systems, Inc. Ocean Sys. Div. One Corporate Place Newport Corporate Park Middleton, RI 02840	(401) 849-5300

PARTICIPANTS AT THE MIDDLE ATMOPSHERE WORKSHOP
LASP - UNIVERSITY OF COLORADO, 17-18 NOVEMBER 1986

NAME	ORGANIZATION (MAILING ADDRESS)	PHONE NUMBER
Grantham, Donald	AGL/LYA Hanscom AFB, MA 01731	(617) 377-2982
Haynes, Peter	University of Cambridge Dept of Applied Math Silver Street Cambridge CB3 9EW ENGLAND	44-223-337866
Hickey, Mike	USRA/NASA MSFC ED44 Houston, TX 77058	(205) 544-5692
Hudson, Robert	NASA/GSFC Code 616 Greenbelt, MD 20771	(301) 286-5485
Katz, Barry S.	OSD/SDIO Pentagon Room 3C444 Washington, DC 20301-7100	(202) 695-8845
Marcos, Frank A.	AFGL/LIS Hanscom AFB, MA 01731	(617) 377-3037
Mendenhall, Larry	AWS/OL-F Los Angeles, CA 90009-2960	(213) 416-7719
Painter, Steve	Space and Naval Warfare Comand PWM-145 Crystal Mall 2, Room 113 Washington, DC 29363-5100	(202) 692-8660

PARTICIPANTS AT THE MIDDLE ATMOPSHERE WORKSHOP
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Rusch, David W.	LASP/University of Colorado Campus Box 392 Boulder, CO 80309-0392	(303) 492-8627
Telford, Jim	Desert Research Institute P.O. Box 60220 Reno, NV 89506	(702) 972-1676
Thomas, Gary E.	LASP/University of Colorado Campus Box 392 Boulder, CO 80309-0392	(303) 492-7022
Thomas, Ronald J.	LASP/University of Colorado Campus Box 392 Boulder, CO 80309-0392	(303) 492-7672

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NAME	ORGANIZATION (MAILING ADDRESS)	PHONE NUMBER
Tomlinson, Ed	SD/DAA X Los Angeles AFS Los Angeles, CA 90009-2960	(213) 416-7720
Twitchell, Paul	Office of Naval Research Arlington, VA 22217-5000	(202) 696-4713
Ulwick, James	Stewart Radiation Lab 139 Great Road Bedford, MA 01730	(617) 275-8273
Vonder Haar, Thomas	METSAT, Inc 515 South Howes Ft. Collins, CO 80521	(303) 221-5420
Vonnegut, Bernard	ASRC SUNY Albany, NY 12222	(518) 442-4499
Wilkerson, Thomas	University of Maryland College Park, MD 20742	(301) 454-5401
Wylie, Donald	Space Science & Engineering Center University of Wisconsin Madison, WI 53706	(608) 263-7458

ENCLOSURE 4.

COPY OF OVERHEAD TRANSPARENCIES PRESENTED AT BOULDER WORKSHOP

- POLAR MESOSPHERIC CLOUD EXPERIMENT

1. Introduction

   - Noctilucent clouds

   - Solar Mesosphere Explorer

2. Scientific Objectives

3. Instrument Descriptions

   - Morphology Experiment

   - Waves Experiment

   - High-resolution (Nadir) Experiment

   - Microphysics Experiment

4. Spacecraft and Mission Requirements

   - Orbit

   - Imaging Product

- SUMMARY OF CLOUD PROPERTIES

1. Spatial and temporal properties

- latitudes above 60 deg.
- occur in both N and S hemispheres
- season begins one month before solstice
- season ends two months after solstice
- maximum activity 15-20 days after solstice
- height - 85.0 1.5 km (north)
- - 83.5 1.5 km (south)
- vertical thickness - 1 to 5 km
- horizontal scales -1 to 1000 km

- SUMMARY OF CLOUD PROPERTIES

2. Optical and physical properties

- generally accepted to be mostly ice
- particle radius $r < 70nm$
- average concentration $n \approx 100$ cm^{-3}
- water vapor content of ice - ≈ 100 μgm-cm^{-3}
- size distribution - narrow dispersion

- SUMMARY OF CLOUD PROPERTIES

3. Controlling or forcing factors

- temperature $< 140K$
- water vapor concentration
- vertical air motion
- turbulence
- weather fronts - perhaps
- sudden mesospheric coolings -perhaps
- no influence from geomagnetic storms, auroras, or solar activity

QUESTIONS REGARDING PMC AND NLC

1. What are the underlying causes ?

2. What is the origin of wave structure ?

3. What is the particle composition ?

4. How do the optical properties relate ?
   to the physical properties ?

5. What is the cause of the spatial
   and temporal variability ?

6. What is the nucleation mechanism ?

7. Is PMC activity directly related to IGW ?

8. How do PMC particles affect the ionization
   properties of the D-region ?

SCIENTIFIC OBJECTIVES

1. Morphology Experiment

To determine the morphology, occurrence frequency, and the distribution of large spatial scales of PMC, and other aerosol layers in the upper mesosphere

2. Waves Experiment

To determine the statistical wave properties down to spatial scales of 10 km (horizontal) and 1 km (vertical)

3. Microphysics Experiment

To determine the mean particle size, and to characterize its dependence on latitude, longitude, wave activity and PMC brightness

4. High Resolution (Nadir) Experiment)

To determine the statistical wave properties to horizontal scales (1x1 km) for brightest PMC

1. MORPHOLOGY EXPERIMENT

- a low-resolution, wide FOV imager
- FOV-~~130~~ 1280 km(cross-track),50 km(vertical)
- Resolution - 40km x 3km in image plane
- In-track resolution - 40 km(due to LOS smearing)
- Number of array elements - 32x16
- Wavelength - 265nm
- geographic coverage - 100% above $60°N$

2. WAVES EXPERIMENT

- a medium-resolution imager
- FOV - 320km(cross-track), 16km(vertical)
- Resolution - 10km x 1km in image plane
- In-track resolution - 40km(due to limb smearing)
- Number of array elements - 32 x 16
- Wavelength - 265nm
- geographic coverage - 25% at $60°N$
  - 100% above $82.8°N$

3. HIGH-RESOLUTION NADIR EXPERIMENT

- Narrow FOV imager
- FOV - 80km(cross-track)
- Resolution - 2.5km(cross-track), 2.5 km(in-track)
- Number of array elements - 32 x 1
- Wavelength - 265nm

4. PMC MICROPHYSICS EXPERIMENT

- A limb-scanning two-color UV polarimeter
- measurements: $I_{\|}, I_{\perp}$ at
  two wavelengths, $= 210nm$ and $= 265nm$
- effective FOV - 175km x 24km
- resolution - 175km in horizontal, 3 km in vertical
- angular coverage at limb - 360°
- number of array elements - 1 x 8
- Method of analysis to retrieve cloud particle parameters-

  Compare polarization and radiance as a function of scattering angle and compare with Mie scattering theory
  to derive $\bar{r}$ =mean particle radius & particle concentration

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